
CLAIMS

[Claim(s)]
[Claim 1] In the manufacture approach of a lamination semi-conductor substrate of pasting up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all The manufacture approach of the semi-conductor substrate characterized by having the process which pastes up two semi-conductor substrates, and the process which heat-treats grinding, the process to grind, and said pasted-up semi-conductor substrate for one [at least] field of said pasted-up semi-conductor substrate at predetermined condition temperature in ambient atmospheres other than an oxidizing quality.
[Claim 2] In the manufacture approach of a lamination semi-conductor substrate of pasting up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all The process which pastes up two semi-conductor substrates, the process which carries out grinding polish of one [at least] field of said pasted-up semi-conductor substrate, and said pasted-up semi-conductor substrate are set in ambient atmospheres other than an oxidizing quality. The manufacture approach of the lamination semi-conductor substrate which is equipped with the process heat-treated at predetermined condition temperature, and is characterized by the surface of one [at least] semi-conductor substrate being 3x1017cm of oxygen densities to less than [3].
[Claim 3] It is the lamination semi-conductor substrate with which each plane of composition where mirror polishing of the two semi-conductor substrates was carried out is directly pasted up, and it is not placed between adhesion sides by the foreign matter. The lamination semi-conductor substrate characterized by having pasted up two semi-conductor substrates and forming one [at least] field of said pasted-up semi-conductor substrate grinding and by grinding and heat-treating said pasted-up semi-conductor substrate at predetermined condition temperature in ambient atmospheres other than an oxidizing quality.
[Claim 4] The lamination semi-conductor substrate characterized by pasting up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out, and being formed using the semi-conductor substrate whose surface of one [at least] semi-conductor substrate it is the lamination semi-conductor substrate with which it is not placed between adhesion sides by the foreign matter at all, and is 3x1017cm of oxygen densities to less than [3].

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the lamination semi-conductor substrate which does not mind the oxide film with which two semi-conductor substrates paste up and are formed.
[0002]
[Description of the Prior Art] Generally, the SOI (Silicon on Insulator) semi-conductor substrate which made the oxide-film layer intervene between two semi-conductor substrates as a lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed, and the lamination semi-conductor substrate on which an oxide film is made to be placed between and pasted up directly or partially are known.
[0003] The lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed sticks the semi-conductor substrate with which the class of impurity differs from the concentration of an impurity, can be unified and can form a lamination semi-conductor substrate.
[0004] In addition, such a lamination semi-conductor substrate can be made into a steep impurity atom concentration profile.
[0005] Moreover, if the lamination semi-conductor substrate which has partial SOI structure is used, a theoretical circuit etc. can be formed in a direct adhesion field to formation of vertical mold power inhibition (for example, VDMOS), and a SOI field. As semi-conductor substrates the intelligent power IC, for next-generation VLSI, etc., the lamination semi-conductor substrate which has this SOI structure attracts attention, and can form various structures.
[0006] It has been a requirement that the above manufacture approaches of a lamination semi-conductor substrate form in a semi-conductor substrate front face the natural oxidation film which has a hydrophilic property in the former.
[0007] In such a conventional approach, there was a problem that the oxide-film layer resulting from the natural oxidation film will be formed, by the semi-conductor substrate adhesion interface which carried out junction-elevated-temperature (1100 degrees C) heat treatment.
[0008] Shingaku Giho SDM of the Institute of Electronics, Information and Communication Engineers issue in order to solve such a trouble -- as indicated by "direct adhesion of the silicon wafer which does not mind the natural oxidation film" 92 to 146 inside First, they are as many fluorines ("F" is called below.) as possible about the front face which is immersed into a high-concentration hydrogen fluoride solution in a semi-conductor substrate, and is joined. It is a hydroxyl group (an "OH radical" is called below.) about F in ultrapure water in said semi-conductor substrate after carrying out termination. firm [between two semi-conductor substrates] by permuting, joining semi-conductor substrates and carrying out elevated-temperature heat treatment (about 1100 degrees C) by the hydrogen bond of this OH radical, -- covalent bond is carried out and a lamination semi-conductor substrate is formed.
[0009] According to said approach, when pasting up semi-conductor substrates directly, it is reported to the adhesion interface that formation of a lamination semi-conductor substrate with very little oxide is

possible.
[0010]
[Problem(s) to be Solved by the Invention] Adhesion of said lamination semi-conductor substrate is performed by the hydrogen bond resulting from sufficient OH radical and the water molecule to which it stuck.
[0011] For this reason, when the OH radical consistency in a semi-conductor substrate front face falls, there is a problem of generating a void, without stabilizing bond strength.
[0012] For this reason, in said approach, the natural oxidation film is formed in a plane of composition, and after performing surface treatment which gives a hydrophilic property, it is pasting up in the room temperature.
[0013] However, by this approach, when it is going to form the lamination semi-conductor substrate which does not have an insulator layer in an adhesion interface, in heat treatment of 1100 degrees C - about 1200 degrees C, the natural oxidation film formed in the plane of composition is not diffused in bulk, but to a junction interface, serves as a layer-like oxidation membrane layer, remains, and has the problem of bringing about the increment in resistance.
[0014] Moreover, a semi-conductor substrate is immersed into a high-concentration hydrogen fluoride solution, and although the field which is a junction interface after heat treatment and does not have an oxide-film layer is formed when ultrapure water performs surface treatment, padding of an oxide film generates said semi-conductor substrate locally, and there is a possibility of becoming an electrical property top problem by this resistance component, after that. In this case, since the OH radical consistency is falling, adhesion at a room temperature becomes weak and has the problem that a poor void occurs.
[0015] Then, this invention aims at offering the approach of manufacturing the lamination semi-conductor substrate with which an oxide film does not exist at all by forming the natural oxidation film in a plane of composition, making stability paste at a room temperature, and removing the oxide film by which it is placed between adhesion interfaces, when pasting up two semi-conductor substrates and forming a lamination semi-conductor substrate.
[0016]
[Means for Solving the Problem] In the manufacture approach of a lamination semi-conductor substrate of invention indicated to the 1st claim of this application pasting up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all It is the manufacture approach of the lamination semi-conductor substrate equipped with the process which pastes up two semi-conductor substrates, and the process which heat-treats grinding, the process to grind, and said pasted-up semi-conductor substrate for one [at least] field of said pasted-up semi-conductor substrate at predetermined condition temperature in ambient atmospheres other than an oxidizing quality.
[0017] Thus, in the lamination semi-conductor substrate which pastes up and forms two semi-conductor substrates, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, 1100 degrees C - 1200 degrees C elevated-temperature heat treatment is performed to the semi-conductor substrate on which two semi-conductor substrates were stuck in lamination and after that, for example, a room temperature. The oxide-film layer by the natural oxidation film will exist in the adhesion interface of the semi-conductor substrate stuck at this time. Then, grinding and after grinding, the oxygen density in the silicon layer of the substrate thin-film-ized by predetermined thickness by grinding and polish is low-concentration-ized by out-diffusion by giving predetermined temperature, for example, 1100 degrees C - 1300 degrees C elevated-temperature heat treatment, in ambient atmospheres other than an oxidizing quality, so that it may become predetermined thickness from the adhesion interface of one [at least] substrate. For this reason, it becomes easy to diffuse the oxide film which exists in an adhesion interface in the low-concentration-ized silicon layer. Therefore, the lamination semi-conductor substrate which does not adhesion mind [of the stuck semi-conductor substrate] an oxide film is manufactured.
[0018] Invention indicated to the 2nd claim of this application is the manufacture approach of a

lamination semi-conductor substrate that the oxygen density of the surface of one [at least] semi-conductor substrate is three or less [3x1017cm -], in the manufacture approach of a lamination semi-conductor substrate of pasting up directly each plane of composition where mirror polishing of said two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all.
[0019] The oxygen density of the surface of one [at least] semi-conductor substrate uses the semi-conductor substrate which is three or less [3x1017cm -] between two semi-conductor substrates which form a lamination semi-conductor substrate. Thus, by said approach It is under [other than the oxidizing quality when the lamination semi-conductor substrate was formed, after being stuck / ambient atmosphere, for example, reducibility or inert atmosphere,] setting. If it heat-treats at predetermined temperature, for example, the temperature of 1100 degrees C - 1300 degrees C, the oxygen density falls, so that the oxygen in a substrate goes to a front face by out-diffusion. If an oxide film exists in the oxygen density fall field on the front face of a substrate to which the oxygen density fell, the oxide film is diffused in the silicon layer. For this reason, since a 3 about [3x1017cm of natural oxidation film extent, for example, an oxygen density, to] thin oxide film is diffused in a silicon layer, the lamination semi-conductor substrate by which an oxide film is not placed between adhesion interfaces is formed by the manufacture approach of this semi-conductor substrate.
[0020] Invention indicated by the 3rd claim of this application pastes up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out. Are the lamination semi-conductor substrate with which it is not placed between adhesion sides by the foreign matter at all, paste up two semi-conductor substrates, do grinding and polish of one [at least] field of said pasted-up semi-conductor substrate, and said pasted-up semi-conductor substrate is set in ambient atmospheres other than an oxidizing quality. It is the lamination semi-conductor substrate with which it is formed by heat-treating at predetermined condition temperature, and is not placed between the planes of composition between semi-conductor substrates by the foreign matter.
[0021] Thus, it sets to the lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed. For example, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, If one [lamination, after that, and / at least] field is thin-film-ized by grinding and polish and is heat-treated after that, for example, the temperature of 1100 degrees C - 1200 degrees C, two semi-conductor substrates Since the oxide film which the oxygen in a substrate is low-concentration-ized by out-diffusion, and exists in the oxygen density fall field of this front face becomes that it is easy to be spread in a substrate, the lamination semi-conductor substrate with which it is not placed between adhesion interfaces by the oxide film is formed.
[0022] Invention indicated by the 4th claim of this application is a lamination semi-conductor substrate with which each plane of composition where mirror polishing of said two semi-conductor substrates was carried out is directly pasted up, and it is not placed between adhesion sides by the foreign matter at all, and is a lamination semi-conductor substrate formed using the semi-conductor substrate whose surface of one [at least] semi-conductor substrate is 3x1017cm of oxygen densities to less than [3].
[0023] Thus, when super-******** of natural oxidation film extent exists in an adhesion interface, by heat-treating two lamination semi-conductor substrates at predetermined temperature, the oxygen in a substrate is low-concentration-ized by out-diffusion, and the oxide film which exists in this oxygen density fall field is spread in a substrate. For this reason, for example, the natural oxidation film which is 3 about [3x1017cm of oxygen densities to] super-******** is diffused in a substrate, and the lamination semi-conductor substrate which does not intervene an oxide film is formed.
[0024] In this case, after two semi-conductor substrates are stuck, heat treatment is performed with predetermined temperature, and the ultra-thin oxide film which is natural oxidation film extent will disappear from a front face in a deep place, so that said heat treatment time amount is so long that the oxygen density in the substrate before said heat treatment is low, when the oxide film by which it is placed between the oxygen and the adhesion interfaces in a substrate is spread.
[0025] Therefore, the oxide film which exists in an adhesion interface is completely removed, so that the

oxygen density in the substrate which forms a lamination semi-conductor substrate is low and heat treatment temperature is high.
[0026]
[Embodiment of the Invention] Hereafter, this invention is explained to a detail based on an example.
[0027] The lamination semi-conductor substrate formed as follows was used for the semi-conductor substrate used for the example concerning this invention.
[0028] Drawing 1 is process drawing showing the manufacture approach of the semi-conductor substrate used for the example of this invention.
[0029] As shown in drawing 1 , the thing of oxygen density 14x1017cm-3 in a substrate was used for two semi-conductor substrates 1 and 2 used for the example of this invention. After performing surface treatment which forms the natural oxidation film 3 in the field of said semi-conductor substrate which turns into a plane of composition at least (inside of drawing 1 (1)), said two semi-conductor substrates 1 and 2 were joined in the room temperature (inside of drawing 1 (2)). Then, predetermined processing shown below was performed and the lamination semi-conductor substrate 4 was formed.
[0030] First, heat treatment of 2 hours was performed for the semi-conductor substrates 1 and 2 stuck at the room temperature in the nitrogen (N2) ambient atmosphere at the temperature of 1100 degrees C. Let the lamination semi-conductor substrate formed by said approach be Sample A. Moreover, let further the lamination semi-conductor substrate which performed 1300-degree C heat treatment be Sample B in an argon (Ar) ambient atmosphere after performing heat treatment of 2 hours at said 1100 degrees C. Moreover, let the lamination semi-conductor substrate 4 which performed heat treatment of 2 hours under the argon (Ar) ambient atmosphere be Sample C at the temperature of 1300 degrees C after sticking 14x1017cm [of said oxygen densities] - two semi-conductor substrates of 3 and carrying out grinding of one semi-conductor substrate from an adhesion interface to 10 micrometers by SG (Surface Grinder) (inside of drawing 1 (3)) (inside of drawing 1 (4)).
[0031] The cross section of the samples A, B, and C of said lamination semi-conductor substrate was observed by TEM (Transmission Electron Microscopy: transmission electron microscope).
[0032] A result is shown in drawing 2 . Drawing 2 is drawing showing the thickness of the embedded oxide film at the time of observing the cross section of said samples A, B, and C by TEM.
[0033] As shown in drawing 2 , as for the sample A which heat-treated under nitrogen-gas-atmosphere mind, the 40A oxide-film layer was observed by the adhesion interface for 1100 degrees C and 2 hours. As mentioned above, Sample A omits 1300 degrees C and heat treatment of 2 hours into the argon (Ar) ambient atmosphere like other samples B and C.
[0034] Moreover, after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours, as for the sample B formed into the argon (Ar) ambient atmosphere, the field where an oxide film does not exist in an adhesion interface at all, and the field where a 200-300A oxide-film layer exists were observed by island shape for 1300 degrees C and 2 hours.
[0035] Moreover, as for the sample C which formed one side of the semi-conductor substrate pasted up after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours in the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours after performing thin film-ization in the thickness of 10 micrometers from an adhesion interface, it was not placed between adhesion interfaces by the oxide film at all.
[0036] The sectional view of Sample C observed by TEM to drawing 3 is shown.
[0037] As shown in drawing 3 , to an adhesion interface, it can check that the oxide film does not intervene.
[0038] From this result, the semi-conductor substrate with which the natural oxidation membrane layer was formed Two-sheet lamination, After thin-film-izing at least one side of said lamination semi-conductor substrate from an adhesion interface to the thickness of 10 micrometers, by performing elevated-temperature heat treatment of 2 hours at 1300 degrees C among argon atmosphere It has checked that the about 40A oxide film which existed in a depth of 10 micrometers from said thin-film-ized semi-conductor substrate disappeared.
[0039] Next, the 2nd example of this invention is explained.

[0040] The lamination semi-conductor substrate formed as follows was used for the semi-conductor substrate used for the example concerning this invention.
[0041] The thing of oxygen density 14x1017cm-3 in a substrate was used for two semi-conductor substrates used for the 2nd example of this invention. The 2100A thermal oxidation film was formed in one semi-conductor substrate of said semi-conductor substrate. Then, after performing surface treatment which forms the natural oxidation film in the field of said semi-conductor substrate which turns into a plane of composition at least, said two semi-conductor substrates were joined in the room temperature. Then, the following processings were performed and the lamination semi-conductor substrate was formed.
[0042] First, after sticking said two semi-conductor substrates, heat treatment of 2 hours was performed in the nitrogen (N2) ambient atmosphere at the temperature of 1100 degrees C. The lamination semi-conductor substrate formed by said approach is made into sample A'. Moreover, after performing heat treatment of 2 hours at said 1100 degrees C, the lamination semi-conductor substrate which performed 1300-degree C heat treatment is further made into sample B' in an argon (Ar) ambient atmosphere. Moreover, after sticking 14x1017cm [of said oxygen densities] - two semi-conductor substrates of 3 and carrying out grinding of one semi-conductor substrate from an adhesion interface to 10 micrometers by SG, the lamination semi-conductor substrate which performed heat treatment of 2 hours under the argon (Ar) ambient atmosphere is made into sample C' at the temperature of 1300 degrees C.
[0043] said -- lamination -- a semi-conductor -- a substrate -- a sample -- A -- ' -- B -- ' -- C -- ' -- a cross section -- TEM -- having observed .
[0044] A result is shown in drawing 4 . drawing 4 -- said -- a sample -- A -- ' -- B -- ' -- C -- ' -- a cross section -- TEM -- having observed -- a case -- embedded -- an oxide film -- thickness -- being shown -- drawing -- it is .
[0045] As shown in drawing 4 , as for sample A' which heat-treated under nitrogen-gas-atmosphere mind, the 2100A oxide-film layer was observed by the adhesion interface for 1100 degrees C and 2 hours. As mentioned above, sample A' omits 1300 degrees C and heat treatment of 2 hours into the argon (Ar) ambient atmosphere like other sample B' and C'.
[0046] Moreover, after heat-treating under 1100-degree-C 2-hour nitrogen-gas-atmosphere mind, the 2100A oxide-film layer was observed by the adhesion interface also in sample B' formed into the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours.
[0047] Moreover, as for sample C' which formed one side of the semi-conductor substrate pasted up after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours in the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours after performing thin film-ization in the thickness of 10 micrometers from an adhesion interface, the 2025A oxide-film layer was observed by the adhesion interface.
[0048] Also in the lamination semi-conductor substrate with which both natural oxidation membrane layers were formed the oxide-film layer of predetermined thickness forms from this result -- having -- said oxide-film layer -- ** -- After one [at least] semi-conductor substrate is thin-film-ized from an adhesion interface to the thickness of 10 micrometers, in argon atmosphere It has checked that the 85A oxide-film layer was removed from the oxide-film layer which existed in a depth of 10 micrometers from said thin-film-ized semi-conductor substrate by performing 1300 degrees C and elevated-temperature heat treatment of 2 hours.
[0049] Therefore, after sticking two semi-conductor substrates at a room temperature, grinding and removal of a semi-conductor substrate are done from the adhesion interface of said stuck semi-conductor substrate at the thickness of 10 micrometers. Then, in ambient atmospheres other than an oxidizing quality, by [of 1300 degrees C and 2 hours] carrying out elevated-temperature heat treatment, out-diffusion of the oxygen in a substrate is carried out, the oxide-film layer which exists in an adhesion interface is spread to the low concentration field of a semi-conductor substrate, and the lamination semi-conductor substrate with which an oxide-film layer does not intervene can be formed.
[0050] Next, the oxygen density in a semi-conductor substrate formed the lamination semi-conductor substrate using the semi-conductor substrate of 14x1018cm-3, and after that, among ambient

atmospheres other than an oxidizing quality, at the 1300-degree C elevated temperature, 2 hours or when it heat-treated, the out-diffusion of oxygen investigated how an oxygen density would change in the depth direction from a front face for 4 hours.
[0051] Drawing 5 is drawing showing the result of having measured the oxygen density in the depth direction.
[0052] According to examples 1 and 2, since the oxide film (oxide film 85A or less) has disappeared from the front face in the location of 10 micrometers, the oxygen density in this location is 3x1017cm-3, and if it is an oxygen density not more than this, an oxide film 85A or less will be diffused in a semi-conductor substrate, and it will disappear. Moreover, when heat treatment of 4 hours is performed at 1300 degrees C, the location which the out-diffusion of oxygen progresses and is set to oxygen density 3x1017cm-3 can turn into a location of 20 micrometers from a front face, and can be extinguished from a front face in a deep location.
[0053] Thus, the oxide film of a deep location is removed from a semi-conductor substrate front face, so that there is so much out-diffusion of oxygen that the oxygen density in a semi-conductor substrate is low.
[0054] Therefore, the oxide film which exists in an adhesion interface is diffused in a semi-conductor substrate by hypoxia-ization of the oxygen density in a semi-conductor substrate, and it becomes possible to form the lamination semi-conductor substrate with which an oxide film does not intervene.
[0055]
[Effect of the Invention] In the manufacture approach of the lamination semi-conductor substrate which does not mind the oxide film with which two semi-conductor substrates paste up and are formed as this invention was explained above Grinding, the process to grind, and said pasted-up semi-conductor substrate are set for the process which pastes up two semi-conductor substrates, and one [at least] field of said pasted-up semi-conductor substrate in ambient atmospheres other than an oxidizing quality. They are the lamination semi-conductor substrate which does not mind the oxide film equipped with the process heat-treated at predetermined condition temperature, and its manufacture approach.
[0056] Thus, in the lamination semi-conductor substrate which pastes up and forms two semi-conductor substrates, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, 1100 degrees C - 1200 degrees C elevated-temperature heat treatment is performed to the semi-conductor substrate on which two semi-conductor substrates were stuck in lamination and after that, for example, a room temperature. The oxide-film layer by the natural oxidation film will exist in the adhesion interface of the semi-conductor substrate stuck at this time. Then, the oxygen density in the silicon layer of the substrate thin-film-ized by predetermined thickness by grinding and polish in the thickness of one [at least] substrate by giving predetermined temperature, for example, 1100 degrees C - 1300 degrees C elevated-temperature heat treatment, to predetermined thickness in ambient atmospheres other than an oxidizing quality after grinding, grinding and is low-concentration-ized by out-diffusion. For this reason, it becomes easy to diffuse the oxide film which exists in an adhesion interface in the low-concentration-ized silicon layer. Therefore, to the adhesion interface of the stuck semi-conductor substrate, the lamination semi-conductor substrate which does not mind an oxide film at all can be obtained.
[0057] When the oxygen density of the surface of one [at least] semi-conductor substrate of two semi-conductor substrates stuck uses the semi-conductor substrate which is three or less [3x1017cm -], moreover, on predetermined temperature and the heat treatment conditions of the conditions of the processing time By out-diffusion, an oxygen density falls, so that it goes to a front face, the oxide film which exists in the oxygen density fall field on this front face of a substrate is spread in a substrate, and the oxygen in a substrate can obtain the lamination semi-conductor substrate with which it is not placed between adhesion interfaces by the oxide film at all.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the manufacture approach of the lamination semi-conductor substrate which does not mind the oxide film with which two semi-conductor substrates paste up and are formed.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Generally, the SOI (Silicon on Insulator) semi-conductor substrate which made the oxide-film layer intervene between two semi-conductor substrates as a lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed, and the lamination semi-conductor substrate on which an oxide film is made to be placed between and pasted up directly or partially are known.
[0003] The lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed sticks the semi-conductor substrate with which the class of impurity differs from the concentration of an impurity, can be unified and can form a lamination semi-conductor substrate.
[0004] In addition, such a lamination semi-conductor substrate can be made into a steep impurity atom concentration profile.
[0005] Moreover, if the lamination semi-conductor substrate which has partial SOI structure is used, a theoretical circuit etc. can be formed in a direct adhesion field to formation of vertical mold power inhibition (for example, VDMOS), and a SOI field. As semi-conductor substrates the intelligent power IC, for next-generation VLSI, etc., the lamination semi-conductor substrate which has this SOI structure attracts attention, and can form various structures.
[0006] It has been a requirement that the above manufacture approaches of a lamination semi-conductor substrate form in a semi-conductor substrate front face the natural oxidation film which has a hydrophilic property in the former.
[0007] In such a conventional approach, there was a problem that the oxide-film layer resulting from the natural oxidation film will be formed, by the semi-conductor substrate adhesion interface which carried out junction-elevated-temperature (1100 degrees C) heat treatment.
[0008] Shingaku Giho SDM of the Institute of Electronics, Information and Communication Engineers issue in order to solve such a trouble -- as indicated by "direct adhesion of the silicon wafer which does not mind the natural oxidation film" 92 to 146 inside First, they are as many fluorines ("F" is called below.) as possible about the front face which is immersed into a high-concentration hydrogen fluoride solution in a semi-conductor substrate, and is joined. It is a hydroxyl group (an "OH radical" is called below.) about F in ultrapure water in said semi-conductor substrate after carrying out termination. firm [between two semi-conductor substrates] by permuting, joining semi-conductor substrates and carrying out elevated-temperature heat treatment (about 1100 degrees C) by the hydrogen bond of this OH radical, -- covalent bond is carried out and a lamination semi-conductor substrate is formed.
[0009] According to said approach, when pasting up semi-conductor substrates directly, it is reported to the adhesion interface that formation of a lamination semi-conductor substrate with very little oxide is possible.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] In the manufacture approach of the lamination semi-conductor substrate which does not mind the oxide film with which two semi-conductor substrates paste up and are formed as this invention was explained above Grinding, the process to grind, and said pasted-up semi-conductor substrate are set for the process which pastes up two semi-conductor substrates, and one [at least] field of said pasted-up semi-conductor substrate in ambient atmospheres other than an oxidizing quality. They are the lamination semi-conductor substrate which does not mind the oxide film equipped with the process heat-treated at predetermined condition temperature, and its manufacture approach.
[0056] Thus, in the lamination semi-conductor substrate which pastes up and forms two semi-conductor substrates, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, 1100 degrees C - 1200 degrees C elevated-temperature heat treatment is performed to the semi-conductor substrate on which two semi-conductor substrates were stuck in lamination and after that, for example, a room temperature. The oxide-film layer by the natural oxidation film will exist in the adhesion interface of the semi-conductor substrate stuck at this time. Then, the oxygen density in the silicon layer of the substrate thin-film-ized by predetermined thickness by grinding and polish in the thickness of one [at least] substrate by giving predetermined temperature, for example, 1100 degrees C - 1300 degrees C elevated-temperature heat treatment, to predetermined thickness in ambient atmospheres other than an oxidizing quality after grinding, grinding and is low-concentration-ized by out-diffusion. For this reason, it becomes easy to diffuse the oxide film which exists in an adhesion interface in the low-concentration-ized silicon layer. Therefore, to the adhesion interface of the stuck semi-conductor substrate, the lamination semi-conductor substrate which does not mind an oxide film at all can be obtained.
[0057] When the oxygen density of the surface of one [at least] semi-conductor substrate of two semi-conductor substrates stuck uses the semi-conductor substrate which is three or less [3x1017cm -], moreover, on predetermined temperature and the heat treatment conditions of the conditions of the processing time By out-diffusion, an oxygen density falls, so that it goes to a front face, the oxide film which exists in the oxygen density fall field on this front face of a substrate is spread in a substrate, and the oxygen in a substrate can obtain the lamination semi-conductor substrate with which it is not placed between adhesion interfaces by the oxide film at all.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Adhesion of said lamination semi-conductor substrate is performed by the hydrogen bond resulting from sufficient OH radical and the water molecule to which it stuck.
[0011] For this reason, when the OH radical consistency in a semi-conductor substrate front face falls, there is a problem of generating a void, without stabilizing bond strength.
[0012] For this reason, in said approach, the natural oxidation film is formed in a plane of composition, and after performing surface treatment which gives a hydrophilic property, it is pasting up in the room temperature.
[0013] However, by this approach, when it is going to form the lamination semi-conductor substrate which does not have an insulator layer in an adhesion interface, in heat treatment of 1100 degrees C - about 1200 degrees C, the natural oxidation film formed in the plane of composition is not diffused in bulk, but to a junction interface, serves as a layer-like oxidation membrane layer, remains, and has the problem of bringing about the increment in resistance.
[0014] Moreover, a semi-conductor substrate is immersed into a high-concentration hydrogen fluoride solution, and although the field which is a junction interface after heat treatment and does not have an oxide-film layer is formed when ultrapure water performs surface treatment, padding of an oxide film generates said semi-conductor substrate locally, and there is a possibility of becoming an electrical property top problem by this resistance component, after that. In this case, since the OH radical consistency is falling, adhesion at a room temperature becomes weak and has the problem that a poor void occurs.
[0015] Then, this invention aims at offering the approach of manufacturing the lamination semi-conductor substrate with which an oxide film does not exist at all by forming the natural oxidation film in a plane of composition, making stability paste at a room temperature, and removing the oxide film by which it is placed between adhesion interfaces, when pasting up two semi-conductor substrates and forming a lamination semi-conductor substrate.

[Translation done.]

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MEANS

[Means for Solving the Problem] In the manufacture approach of a lamination semi-conductor substrate of invention indicated to the 1st claim of this application pasting up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all It is the manufacture approach of the lamination semi-conductor substrate equipped with the process which pastes up two semi-conductor substrates, and the process which heat-treats grinding, the process to grind, and said pasted-up semi-conductor substrate for one [at least] field of said pasted-up semi-conductor substrate at predetermined condition temperature in ambient atmospheres other than an oxidizing quality.
[0017] Thus, in the lamination semi-conductor substrate which pastes up and forms two semi-conductor substrates, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, 1100 degrees C - 1200 degrees C elevated-temperature heat treatment is performed to the semi-conductor substrate on which two semi-conductor substrates were stuck in lamination and after that, for example, a room temperature. The oxide-film layer by the natural oxidation film will exist in the adhesion interface of the semi-conductor substrate stuck at this time. Then, grinding and after grinding, the oxygen density in the silicon layer of the substrate thin-film-ized by predetermined thickness by grinding and polish is low-concentration-ized by out-diffusion by giving predetermined temperature, for example, 1100 degrees C - 1300 degrees C elevated-temperature heat treatment, in ambient atmospheres other than an oxidizing quality, so that it may become predetermined thickness from the adhesion interface of one [at least] substrate. For this reason, it becomes easy to diffuse the oxide film which exists in an adhesion interface in the low-concentration-ized silicon layer. Therefore, the lamination semi-conductor substrate which does not adhesion mind [of the stuck semi-conductor substrate] an oxide film is manufactured.
[0018] Invention indicated to the 2nd claim of this application is the manufacture approach of a lamination semi-conductor substrate that the oxygen density of the surface of one [at least] semi-conductor substrate is three or less [3x1017cm -], in the manufacture approach of a lamination semi-conductor substrate of pasting up directly each plane of composition where mirror polishing of said two semi-conductor substrates was carried out, and not being placed between adhesion sides by the foreign matter at all.
[0019] The oxygen density of the surface of one [at least] semi-conductor substrate uses the semi-conductor substrate which is three or less [3x1017cm -] between two semi-conductor substrates which form a lamination semi-conductor substrate. Thus, by said approach It is under [other than the oxidizing quality when the lamination semi-conductor substrate was formed, after being stuck / ambient atmosphere, for example, reducibility or inert atmosphere,] setting. If it heat-treats at predetermined temperature, for example, the temperature of 1100 degrees C - 1300 degrees C, the oxygen density falls, so that the oxygen in a substrate goes to a front face by out-diffusion. If an oxide film exists in the oxygen density fall field on the front face of a substrate to which the oxygen density fell, the oxide film is diffused in the silicon layer. For this reason, since a 3 about [3x1017cm of natural oxidation film extent, for example, an oxygen density, to] thin oxide film is diffused in a silicon layer, the lamination

semi-conductor substrate by which an oxide film is not placed between adhesion interfaces is formed by the manufacture approach of this semi-conductor substrate.
[0020] Invention indicated by the 3rd claim of this application pastes up directly each plane of composition where mirror polishing of the two semi-conductor substrates was carried out. Are the lamination semi-conductor substrate with which it is not placed between adhesion sides by the foreign matter at all, paste up two semi-conductor substrates, do grinding and polish of one [at least] field of said pasted-up semi-conductor substrate, and said pasted-up semi-conductor substrate is set in ambient atmospheres other than an oxidizing quality. It is the lamination semi-conductor substrate with which it is formed by heat-treating at predetermined condition temperature, and is not placed between the planes of composition between semi-conductor substrates by the foreign matter.
[0021] Thus, it sets to the lamination semi-conductor substrate with which two semi-conductor substrates paste up and are formed. For example, after performing surface treatment which forms the natural oxidation film in a plane of composition, and gives a hydrophilic property, If one [lamination, after that, and / at least] field is thin-film-ized by grinding and polish and is heat-treated after that, for example, the temperature of 1100 degrees C - 1200 degrees C, two semi-conductor substrates Since the oxide film which the oxygen in a substrate is low-concentration-ized by out-diffusion, and exists in the oxygen density fall field of this front face becomes that it is easy to be spread in a substrate, the lamination semi-conductor substrate with which it is not placed between adhesion interfaces by the oxide film is formed.
[0022] Invention indicated by the 4th claim of this application is a lamination semi-conductor substrate with which each plane of composition where mirror polishing of said two semi-conductor substrates was carried out is directly pasted up, and it is not placed between adhesion sides by the foreign matter at all, and is a lamination semi-conductor substrate formed using the semi-conductor substrate whose surface of one [at least] semi-conductor substrate is 3x1017cm of oxygen densities to less than [3].
[0023] Thus, when super-******** of natural oxidation film extent exists in an adhesion interface, by heat-treating two lamination semi-conductor substrates at predetermined temperature, the oxygen in a substrate is low-concentration-ized by out-diffusion, and the oxide film which exists in this oxygen density fall field is spread in a substrate. For this reason, for example, the natural oxidation film which is 3 about [3x1017cm of oxygen densities to] super-******** is diffused in a substrate, and the lamination semi-conductor substrate which does not intervene an oxide film is formed.
[0024] In this case, after two semi-conductor substrates are stuck, heat treatment is performed with predetermined temperature, and the ultra-thin oxide film which is natural oxidation film extent will disappear from a front face in a deep place, so that said heat treatment time amount is so long that the oxygen density in the substrate before said heat treatment is low, when the oxide film by which it is placed between the oxygen and the adhesion interfaces in a substrate is spread.
[0025] Therefore, the oxide film which exists in an adhesion interface is completely removed, so that the oxygen density in the substrate which forms a lamination semi-conductor substrate is low and heat treatment temperature is high.
[0026]
[Embodiment of the Invention] Hereafter, this invention is explained to a detail based on an example.
[0027] The lamination semi-conductor substrate formed as follows was used for the semi-conductor substrate used for the example concerning this invention.
[0028] Drawing 1 is process drawing showing the manufacture approach of the semi-conductor substrate used for the example of this invention.
[0029] As shown in drawing 1 , the thing of oxygen density 14x1017cm-3 in a substrate was used for two semi-conductor substrates 1 and 2 used for the example of this invention. After performing surface treatment which forms the natural oxidation film 3 in the field of said semi-conductor substrate which turns into a plane of composition at least (inside of drawing 1 (1)), said two semi-conductor substrates 1 and 2 were joined in the room temperature (inside of drawing 1 (2)). Then, predetermined processing shown below was performed and the lamination semi-conductor substrate 4 was formed.
[0030] First, heat treatment of 2 hours was performed for the semi-conductor substrates 1 and 2 stuck at

the room temperature in the nitrogen (N2) ambient atmosphere at the temperature of 1100 degrees C. Let the lamination semi-conductor substrate formed by said approach be Sample A. Moreover, let further the lamination semi-conductor substrate which performed 1300-degree C heat treatment be Sample B in an argon (Ar) ambient atmosphere after performing heat treatment of 2 hours at said 1100 degrees C. Moreover, let the lamination semi-conductor substrate 4 which performed heat treatment of 2 hours under the argon (Ar) ambient atmosphere be Sample C at the temperature of 1300 degrees C after sticking 14x1017cm [of said oxygen densities] - two semi-conductor substrates of 3 and carrying out grinding of one semi-conductor substrate from an adhesion interface to 10 micrometers by SG (Surface Grinder) (inside of drawing 1 (3)) (inside of drawing 1 (4)).
[0031] The cross section of the samples A, B, and C of said lamination semi-conductor substrate was observed by TEM (Transmission Electron Microscopy: transmission electron microscope).
[0032] A result is shown in drawing 2 . Drawing 2 is drawing showing the thickness of the embedded oxide film at the time of observing the cross section of said samples A, B, and C by TEM.
[0033] As shown in drawing 2 , as for the sample A which heat-treated under nitrogen-gas-atmosphere mind, the 40A oxide-film layer was observed by the adhesion interface for 1100 degrees C and 2 hours. As mentioned above, Sample A omits 1300 degrees C and heat treatment of 2 hours into the argon (Ar) ambient atmosphere like other samples B and C.
[0034] Moreover, after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours, as for the sample B formed into the argon (Ar) ambient atmosphere, the field where an oxide film does not exist in an adhesion interface at all, and the field where a 200-300A oxide-film layer exists were observed by island shape for 1300 degrees C and 2 hours.
[0035] Moreover, as for the sample C which formed one side of the semi-conductor substrate pasted up after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours in the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours after performing thin film-ization in the thickness of 10 micrometers from an adhesion interface, it was not placed between adhesion interfaces by the oxide film at all.
[0036] The sectional view of Sample C observed by TEM to drawing 3 is shown.
[0037] As shown in drawing 3 , to an adhesion interface, it can check that the oxide film does not intervene.
[0038] From this result, the semi-conductor substrate with which the natural oxidation membrane layer was formed Two-sheet lamination, After thin-film-izing at least one side of said lamination semi-conductor substrate from an adhesion interface to the thickness of 10 micrometers, by performing elevated-temperature heat treatment of 2 hours at 1300 degrees C among argon atmosphere It has checked that the about 40A oxide film which existed in a depth of 10 micrometers from said thin-film-ized semi-conductor substrate disappeared.
[0039] Next, the 2nd example of this invention is explained.
[0040] The lamination semi-conductor substrate formed as follows was used for the semi-conductor substrate used for the example concerning this invention.
[0041] The thing of oxygen density 14x1017cm-3 in a substrate was used for two semi-conductor substrates used for the 2nd example of this invention. The 2100A thermal oxidation film was formed in one semi-conductor substrate of said semi-conductor substrate. Then, after performing surface treatment which forms the natural oxidation film in the field of said semi-conductor substrate which turns into a plane of composition at least, said two semi-conductor substrates were joined in the room temperature. Then, the following processings were performed and the lamination semi-conductor substrate was formed.
[0042] First, after sticking said two semi-conductor substrates, heat treatment of 2 hours was performed in the nitrogen (N2) ambient atmosphere at the temperature of 1100 degrees C. The lamination semi-conductor substrate formed by said approach is made into sample A'. Moreover, after performing heat treatment of 2 hours at said 1100 degrees C, the lamination semi-conductor substrate which performed 1300-degree C heat treatment is further made into sample B' in an argon (Ar) ambient atmosphere. Moreover, after sticking 14x1017cm [of said oxygen densities] - two semi-conductor substrates of 3

and carrying out grinding of one semi-conductor substrate from an adhesion interface to 10 micrometers by SG, the lamination semi-conductor substrate which performed heat treatment of 2 hours under the argon (Ar) ambient atmosphere is made into sample C' at the temperature of 1300 degrees C.
[0043] said -- lamination -- a semi-conductor -- a substrate -- a sample -- A -- ' -- B -- ' -- C -- ' -- a cross section -- TEM -- having observed .
[0044] A result is shown in drawing 4 . drawing 4 -- said -- a sample -- A -- ' -- B -- ' -- C -- ' -- a cross section -- TEM -- having observed -- a case -- embedded -- an oxide film -- thickness -- being shown -- drawing -- it is .
[0045] As shown in drawing 4 , as for sample A' which heat-treated under nitrogen-gas-atmosphere mind, the 2100A oxide-film layer was observed by the adhesion interface for 1100 degrees C and 2 hours. As mentioned above, sample A' omits 1300 degrees C and heat treatment of 2 hours into the argon (Ar) ambient atmosphere like other sample B' and C'.
[0046] Moreover, after heat-treating under 1100-degree-C 2-hour nitrogen-gas-atmosphere mind, the 2100A oxide-film layer was observed by the adhesion interface also in sample B' formed into the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours.
[0047] Moreover, as for sample C' which formed one side of the semi-conductor substrate pasted up after heat-treating under nitrogen-gas-atmosphere mind for 1100 degrees C and 2 hours in the argon (Ar) ambient atmosphere for 1300 degrees C and 2 hours after performing thin film-ization in the thickness of 10 micrometers from an adhesion interface, the 2025A oxide-film layer was observed by the adhesion interface.
[0048] Also in the lamination semi-conductor substrate with which both natural oxidation membrane layers were formed the oxide-film layer of predetermined thickness forms from this result -- having -- said oxide-film layer -- ** -- After one [at least] semi-conductor substrate is thin-film-ized from an adhesion interface to the thickness of 10 micrometers, in argon atmosphere It has checked that the 85A oxide-film layer was removed from the oxide-film layer which existed in a depth of 10 micrometers from said thin-film-ized semi-conductor substrate by performing 1300 degrees C and elevated-temperature heat treatment of 2 hours.
[0049] Therefore, after sticking two semi-conductor substrates at a room temperature, grinding and removal of a semi-conductor substrate are done from the adhesion interface of said stuck semi-conductor substrate at the thickness of 10 micrometers. Then, in ambient atmospheres other than an oxidizing quality, by [of 1300 degrees C and 2 hours] carrying out elevated-temperature heat treatment, out-diffusion of the oxygen in a substrate is carried out, the oxide-film layer which exists in an adhesion interface is spread to the low concentration field of a semi-conductor substrate, and the lamination semi-conductor substrate with which an oxide-film layer does not intervene can be formed.
[0050] Next, the oxygen density in a semi-conductor substrate formed the lamination semi-conductor substrate using the semi-conductor substrate of 14x1018cm-3, and after that, among ambient atmospheres other than an oxidizing quality, at the 1300-degree C elevated temperature, 2 hours or when it heat-treated, the out-diffusion of oxygen investigated how an oxygen density would change in the depth direction from a front face for 4 hours.
[0051] Drawing 5 is drawing showing the result of having measured the oxygen density in the depth direction.
[0052] According to examples 1 and 2, since the oxide film (oxide film 85A or less) has disappeared from the front face in the location of 10 micrometers, the oxygen density in this location is 3x1017cm-3, and if it is an oxygen density not more than this, an oxide film 85A or less will be diffused in a semi-conductor substrate, and it will disappear. Moreover, when heat treatment of 4 hours is performed at 1300 degrees C, the location which the out-diffusion of oxygen progresses and is set to oxygen density 3x1017cm-3 can turn into a location of 20 micrometers from a front face, and can be extinguished from a front face in a deep location.
[0053] Thus, the oxide film of a deep location is removed from a semi-conductor substrate front face, so that there is so much out-diffusion of oxygen that the oxygen density in a semi-conductor substrate is low.

[0054] Therefore, the oxide film which exists in an adhesion interface is diffused in a semi-conductor substrate by hypoxia-ization of the oxygen density in a semi-conductor substrate, and it becomes possible to form the lamination semi-conductor substrate with which an oxide film does not intervene.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is process drawing in which starting the example of this invention and showing the manufacture approach of a lamination semi-conductor substrate.
[Drawing 2] It is drawing which measured the thickness of the oxide film by which it is placed between the adhesion interfaces of the lamination semi-conductor substrate which was applied to the example of this invention and formed by each processing.
[Drawing 3] It is drawing which was applied to the example of this invention and measured the cross section of the sample C of the formed lamination semi-conductor substrate by TEM.
[Drawing 4] It is drawing which measured the thickness of the oxide film by which it is placed between the adhesion interfaces of the lamination semi-conductor substrate which was applied to the 2nd example of this invention and formed by each processing.
[Drawing 5] It is drawing in which starting the example of this invention and showing the oxygen density in a semi-conductor substrate, and the relation of the depth from the front face where an oxide film disappears.
[Description of Notations]
1 Semi-conductor Substrate
2 Semi-conductor Substrate
3 Natural Oxidation Film
4 Lamination Semi-conductor Substrate
5 Lamination Semi-conductor Substrate

[Translation done.]

EUROPEAN PATENT OFFICE

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APPLICANT : SUMITOMO METAL IND LTD;

INVENTOR : ADACHI HISASHI;

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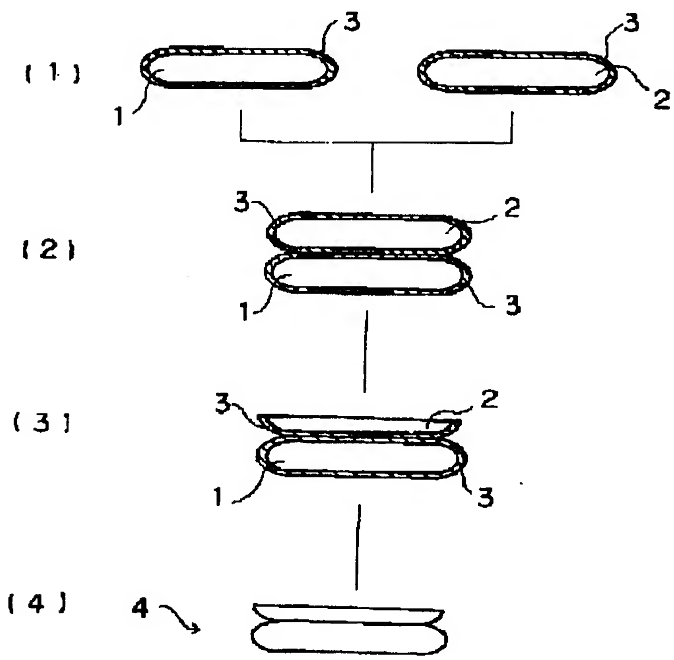
TITLE : LAMINATED SEMICONDUCTOR BOARD AND MANUFACTURE THEREOF



ABSTRACT : PROBLEM TO BE SOLVED: To manufacture a laminated semiconductor board where no oxide film is present by a method, wherein a natural oxide film is formed and is bonded stably on a bonding surface at a room temperature, and an oxide film present at a bonding interface is removed, when two semiconductor boards are laminated and bonded together into a laminated semiconductor board.

SOLUTION: A laminated semiconductor board which is formed by bonding two semiconductor boards together and where no foreign object is present at a bonding interface is manufactured through a method in which two semiconductor boards 1 and 2 where a natural oxide film layer 3 is formed respectively are bonded together, the one surface of the bonded semiconductor boards 1 and 2 is grounded down and polished, and the bonded semiconductor boards 1 and 2 are heat treated in a nonoxidizing atmosphere at a prescribed temperature, where by a laminated semiconductor board 4 where no oxide film is present at a bonding interface can be formed.

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(71)出願人 000002118
住友金属工業株式会社
大阪府大阪市中央区北浜４丁目５番33号

(72)発明者 池田 安伸
佐賀県杵島郡江北町大字上小田2201番地
住友シチックス株式会社内

(72)発明者 足立 尚志
佐賀県杵島郡江北町大字上小田2201番地
住友シチックス株式会社内

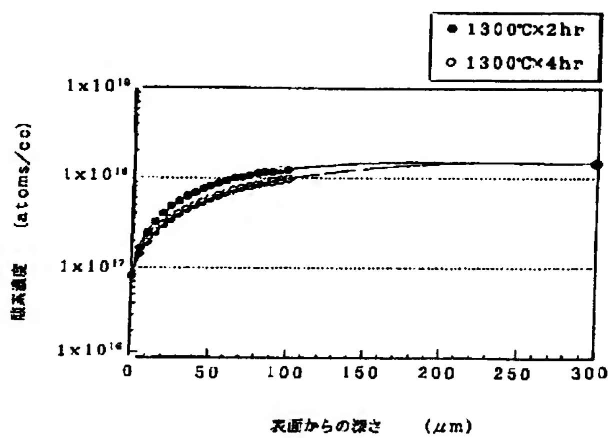
(74)代理人 100082784
弁理士 森 正澄

(54)【発明の名称】 貼り合わせ半導体基板及びその製造方法

(57)【要約】

【課題】 ２枚の半導体基板を接着して貼り合わせ半導体基板を形成する場合に、接合面に自然酸化膜を形成して室温で安定に接着させ、接着界面に介在する酸化膜を除去することにより、全く酸化膜が存在しない貼り合わせ半導体基板を製造する方法を提供すること。

【課題解決手段】 ２枚の半導体基板が接着されて形成される接着界面に全く異物を介在させない貼り合わせ半導体基板の製造方法において、自然酸化膜層３が形成された２枚の半導体基板１，２を接着し、前記接着された半導体基板１，２の少なくとも一方の面を研削・研磨した後、前記接着された半導体基板１，２を、酸化性以外の雰囲気中において、所定条件温度にて熱処理することにより、接着界面に酸化膜を介在させない貼り合わせ半導体基板４を形成した。



【特許請求の範囲】

【請求項1】　2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板の製造方法において、
2枚の半導体基板を接着する工程と、
前記接着された半導体基板の少なくとも一方の面を研削・研磨する工程と、
前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理する工程を備えたことを特徴とする半導体基板の製造方法。

【請求項2】　2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板の製造方法において、
2枚の半導体基板を接着する工程と、
前記接着された半導体基板の少なくとも一方の面を研削研磨する工程と、
前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理する工程を備え、
少なくとも一方の半導体基板の表層が酸素濃度$3\times10^{17}cm^{-3}$以下であることを特徴とする貼り合わせ半導体基板の製造方法。

【請求項3】　2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に異物が介在しない貼り合わせ半導体基板であって、
2枚の半導体基板を接着し、
前記接着された半導体基板の少なくとも一方の面を研削・研磨し、
前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理することにより形成されたことを特徴とする貼り合わせ半導体基板。

【請求項4】　2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板であって、
少なくとも一方の半導体基板の表層が酸素濃度$3\times10^{17}cm^{-3}$以下である半導体基板を用いて形成されることを特徴とする貼り合わせ半導体基板。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、2枚の半導体基板が接着されて形成される酸化膜を介さない貼り合わせ半導体基板の製造方法に関するものである。

【0002】

【従来の技術】一般に、2枚の半導体基板が接着されて形成される貼り合わせ半導体基板として、2枚の半導体基板の間に酸化膜層を介在させたSOI（Silicon on Insulator）半導体基板と、直接又は部分的に酸化膜を介在させて接着させる貼り合わせ半導体基板が知られている。

【0003】2枚の半導体基板が接着されて形成される貼り合わせ半導体基板は、不純物の種類や不純物の濃度が異なる半導体基板を貼り合わせて、一体化し貼り合わせ半導体基板を形成することができる。

【0004】その他、このような貼り合わせ半導体基板は、急峻な不純物濃度分布とすることができる。

【0005】また、部分的なSOI構造を有する貼り合わせ半導体基板を用いれば、直接接着領域に縦型パワー阻止（例えば、VDMOS）の形成や、SOI領域に理論回路等を形成することができる。このSOI構造を有する貼り合わせ半導体基板は、インテリジェントパワーICや、次世代VLSI用などの半導体基板として、注目されており、種々の構造を形成することが可能である。

【0006】前述のような貼り合わせ半導体基板の製造方法は、従来において、半導体基板表面に親水性を有する自然酸化膜を形成することが必要条件となっている。

【0007】このような従来方法においては、接合一高温（1100℃）熱処理した半導体基板接着界面では、自然酸化膜に起因する酸化膜層が形成されてしまうという問題があった。

【0008】このような問題点を解決するため、例えば、電子情報通信学会発行の信学技報SDM92－146中「自然酸化膜を介さないシリコンウエハの直接接着」に記載されているように、まず、半導体基板を高濃度のフッ化水素溶液中に浸漬し、接合される表面をできるだけ多くのフッ素（以下「F」と称する。）で終端させた後、前記半導体基板を超純水中で、Fを水酸基（以下「OH基」と称する。）に置換し、このOH基の水素結合により、半導体基板同士を接合させて、高温熱処理（1100℃程度）することにより、2枚の半導体基板間に強固な共有結合して、貼り合わせ半導体基板を形成する。

【0009】前記方法によれば、半導体基板同士を直接接着する場合においても、接着界面に酸化物が極めて少ない貼り合わせ半導体基板の形成が可能であることが報告されている。

【0010】

【発明が解決しようとする課題】前記貼り合わせ半導体基板の接着は、十分なOH基及び吸着した水分子に起因する水素結合により行われている。

【0011】このため、半導体基板表面におけるOH基密度が低下すると、接着強度が安定せずに、ボイドを発生するという問題がある。

【0012】このため、前記方法においては、接合面に自然酸化膜を形成して、親水性を持たせる表面処理を行った後に、室温中で接着を行っている。

【0013】しかし、この方法では、接着界面に絶縁膜のない貼り合わせ半導体基板を形成しようとする場合、接合面に形成された自然酸化膜は、1100℃～1200℃程度の熱処理では、バルク中に拡散せず、接合界面に層状の酸化膜層となって残留し、抵抗増加をもたらす

という問題がある。

【0014】また、半導体基板を高濃度のフッ化水素溶液中に浸漬し、その後、前記半導体基板を超純水で表面処理を行った場合は、熱処理後の接合界面で、酸化膜層のない領域が形成されるが、局所的に酸化膜の塊りが発生し、この抵抗成分によって、電気特性上問題となるおそれがある。この場合に、OH基密度が低下しているため、室温での接着は弱くなり、ボイド不良が発生するという問題がある。

【0015】そこで、本発明は、2枚の半導体基板を接着して貼り合わせ半導体基板を形成する場合に、接合面に自然酸化膜を形成して室温で安定に接着させ、接着界面に介在する酸化膜を除去することにより、全く酸化膜が存在しない貼り合わせ半導体基板を製造する方法を提供することを目的としている。

【0016】

【課題を解決するための手段】本願第1請求項に記載した発明は、2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板の製造方法において、2枚の半導体基板を接着する工程と、前記接着された半導体基板の少なくとも一方の面を研削・研磨する工程と、前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理する工程を備えた貼り合わせ半導体基板の製造方法である。

【0017】このように、2枚の半導体基板を接着して形成する貼り合わせ半導体基板において、例えば、接合面に自然酸化膜を形成して親水性を持たせる表面処理を行った後、2枚の半導体基板を貼り合わせ、その後、例えば、室温中で貼り合わせられた半導体基板に1100℃～1200℃の高温熱処理を行う。このときに貼り合わせられた半導体基板の接着界面には、自然酸化膜による酸化膜層が存在していることとなる。その後、少なくとも一方の基板の接着界面から所定の厚さとなるように研削・研磨した後、酸化性以外の雰囲気中で、所定温度、例えば、1100℃～1300℃の高温熱処理を施すことにより、研削・研磨で所定厚さに薄膜化された基板のシリコン層中の酸素濃度は、外方拡散により低濃度化される。このため、接着界面に存在する酸化膜は、低濃度化されたシリコン層中に拡散しやすくなる。従って、貼り合わせられた半導体基板の接着界面には、酸化膜を介さない貼り合わせ半導体基板が製造される。

【0018】本願第2請求項に記載した発明は、前記2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板の製造方法において、少なくとも一方の半導体基板の表層の酸素濃度が、$3\times10^{17}cm^{-3}$以下である貼り合わせ半導体基板の製造方法である。

【0019】このように、貼り合わせ半導体基板を形成する2枚の半導体基板のうち、少なくとも一方の半導体基板の表層の酸素濃度が、$3\times10^{17}cm^{-3}$以下である半導体基板を用いて、前記方法により、貼り合わせ半導体基板を形成すると、貼り合わせられた後、酸化性以外の雰囲気中、例えば、還元性又は不活性雰囲気中において、所定温度、例えば、1100℃～1300℃の温度で熱処理されると、基板中の酸素は、外方拡散により、表面にいくほど酸素濃度が低下していく。酸素濃度が低下した基板表面の酸素濃度低下領域に酸化膜が存在すると、酸化膜は、シリコン層中に拡散されていく。このため、自然酸化膜程度、例えば、酸素濃度$3\times10^{17}cm^{-3}$程度の薄酸化膜は、シリコン層中に拡散されるため、この半導体基板の製造方法により、接着界面に酸化膜を介在しない、貼り合わせ半導体基板が形成される。

【0020】本願第3請求項に記載された発明は、2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板であって、2枚の半導体基板を接着し、前記接着された半導体基板の少なくとも一方の面を研削・研磨し、前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理することにより形成され、半導体基板間の接合面に異物が介在しない貼り合わせ半導体基板である。

【0021】このように、2枚の半導体基板が接着されて形成される貼り合わせ半導体基板において、例えば、接合面に自然酸化膜を形成して親水性を持たせる表面処理を行った後、2枚の半導体基板を貼り合わせ、その後、少なくとも一方の面を研削・研磨により薄膜化し、その後、例えば、1100℃～1200℃の温度で熱処理を行うと、外方拡散により基板中の酸素が低濃度化され、この表面の酸素濃度低下領域に存在する酸化膜は、基板中に拡散されやすくなるため、接着界面に酸化膜が介在しない貼り合わせ半導体基板が形成される。

【0022】本願第4請求項に記載された発明は、前記2枚の半導体基板の鏡面研磨された各接合面を直接接着して、接着面に全く異物が介在しない貼り合わせ半導体基板であって、少なくとも一方の半導体基板の表層が酸素濃度$3\times10^{17}cm^{-3}$以下である半導体基板を用いて形成される貼り合わせ半導体基板である。

【0023】このように、自然酸化膜程度の超薄酸化膜が接着界面に存在する場合、2枚の貼り合わせ半導体基板を所定温度で熱処理することにより、基板中の酸素が外方拡散により低濃度化され、この酸素濃度低下領域に存在する酸化膜が、基板中に拡散する。このため、例えば、酸素濃度$3\times10^{17}cm^{-3}$程度の超薄酸化層である自然酸化膜は基板中に拡散されて、酸化膜を介在しない貼り合わせ半導体基板が形成される。

【0024】この場合、2枚の半導体基板が貼り合わせられた後、所定温度によって熱処理が施されて、基板中の酸素及び接着界面に介在する酸化膜が拡散する場合は、前記熱処理前の基板中の酸素濃度が低いほど、か

つ、前記熱処理時間が長い程、自然酸化膜程度の極薄酸化膜は、表面から深いところで消滅することとなる。

【0025】従って、貼り合わせ半導体基板を形成する基板中の酸素濃度が低く、かつ、熱処理温度が高い程、接着界面に存在する酸化膜が完全に除去される。

【0026】

【発明の実施の形態】以下、本発明を具体例に基づいて詳細に説明する。

【0027】本発明に係る具体例に用いる半導体基板は、以下のように形成した貼り合わせ半導体基板を用いた。

【0028】図1は、本発明の具体例に用いた半導体基板の製造方法を示す工程図である。

【0029】図1に示すように、本発明の具体例に用いた２枚の半導体基板１，２は、基板中の酸素濃度$14\times10^{17}cm^{-3}$のものを用いた。前記半導体基板の少なくとも接合面となる面に自然酸化膜３を形成する表面処理を行った後（図1中（１））、前記２枚の半導体基板１，２を室温中で接合させた（図1中（２））。その後、以下に示す所定処理を行い、貼り合わせ半導体基板４を形成した。

【0030】まず、室温で貼り合わせた半導体基板１，２を温度１１００℃で、２時間の熱処理を窒素（N2）雰囲気中で行った。前記方法で形成した貼り合わせ半導体基板をサンプルＡとする。また、前記１１００℃で２時間の熱処理を行った後、更に、アルゴン（Ａｒ）雰囲気中で、１３００℃の熱処理を行った貼り合わせ半導体基板をサンプルＢとする。また、前記酸素濃度$14\times10^{17}cm^{-3}$の半導体基板２枚を貼り合わせた後、一方の半導体基板をＳＧ（Surface Grinder）で接着界面から１０μｍまで研削した後（図1中（３））、温度１３００℃で、２時間の熱処理をアルゴン（Ａｒ）雰囲気下で行った貼り合わせ半導体基板４をサンプルＣとする（図1中（４））。

【0031】前記貼り合わせ半導体基板のサンプルＡ，Ｂ，Ｃの断面をＴＥＭ（Transmission Electron Microscopy：透過型電子顕微鏡）で観察した。

【0032】結果を図2に示す。図2は、前記サンプルＡ，Ｂ，Ｃの断面をＴＥＭで観察した場合の埋込酸化膜の厚さを示す図である。

【0033】図2に示すように、１１００℃、２時間、窒素雰囲気下で熱処理を行ったサンプルＡは、接着界面に４０オングストロームの酸化膜層が観察された。前述したように、サンプルＡは、他のサンプルＢ，Ｃのように、アルゴン（Ａｒ）雰囲気中において、１３００℃、２時間の熱処理は行っていない。

【0034】また、１１００℃、２時間、窒素雰囲気下で熱処理を行った後、１３００℃、２時間、アルゴン（Ａｒ）雰囲気中において形成したサンプルＢは、接着界面に酸化膜が全く存在しない領域と、２００～３００オングストロームの酸化膜層が存在する領域が島状に観察された。

【0035】また、１１００℃、２時間、窒素雰囲気下で熱処理を行った後、接着された半導体基板の一方を接着界面から１０μｍの厚さに薄膜化を行った後に、１３００℃、２時間、アルゴン（Ａｒ）雰囲気中で形成したサンプルＣは、接着界面に全く酸化膜が介在していなかった。

【0036】図3に、ＴＥＭで観察したサンプルＣの断面図を示す。

【0037】図3に示すように、接着界面には、酸化膜が介在していないことが確認できる。

【0038】この結果から、自然酸化膜層が形成された半導体基板を２枚貼り合わせ、前記貼り合わせ半導体基板の少なくとも一方を接着界面から１０μｍの厚さまで薄膜化した後、アルゴン雰囲気中、１３００℃で２時間の高温熱処理を施すことにより、前記薄膜化された半導体基板から１０μｍの深さに存在していた４０オングストローム程度の酸化膜が消滅することが確認できた。

【0039】次に、本発明の第２の具体例について説明する。

【0040】本発明に係る具体例に用いる半導体基板は、以下のように形成した貼り合わせ半導体基板を用いた。

【0041】本発明の第２の具体例に用いた２枚の半導体基板は、基板中の酸素濃度$14\times10^{17}cm^{-3}$のものを用いた。前記半導体基板の一方の半導体基板に２１００オングストロームの熱酸化膜を形成した。その後、前記半導体基板の少なくとも接合面となる面に自然酸化膜を形成する表面処理を行った後、前記２枚の半導体基板を室温中で接合させた。その後、以下の処理を行って、貼り合わせ半導体基板を形成した。

【0042】まず、前記２枚の半導体基板を貼り合わせた後、温度１１００℃で、２時間の熱処理を窒素（N_2）雰囲気中で行った。前記方法で形成した貼り合わせ半導体基板をサンプルＡ'とする。また、前記１１００℃で２時間の熱処理を行った後、更に、アルゴン（Ａｒ）雰囲気中で、１３００℃の熱処理を行った貼り合わせ半導体基板をサンプルＢ'とする。また、前記酸素濃度$14\times10^{17}cm^{-3}$の半導体基板２枚を貼り合わせた後、一方の半導体基板をＳＧで接着界面から１０μｍまで研削した後、温度１３００℃で、２時間の熱処理をアルゴン（Ａｒ）雰囲気下で行った貼り合わせ半導体基板をサンプルＣ'とする。

【0043】前記貼り合わせ半導体基板のサンプルＡ'，Ｂ'，Ｃ'の断面をＴＥＭで観察した。

【0044】結果を図4に示す。図4は、前記サンプルＡ'，Ｂ'，Ｃ'の断面をＴＥＭで観察した場合の埋込酸化膜の厚さを示す図である。

【0045】図4に示すように、１１００℃、２時間、

窒素雰囲気下で熱処理を行ったサンプルＡ’は、接着界面に２１００オングストロームの酸化膜層が観察された。前述したように、サンプルＡ’は、他のサンプルＢ’，Ｃ’のように、アルゴン（Ａｒ）雰囲気中において、１３００℃、２時間の熱処理は行っていない。

【００４６】また、１１００℃２時間窒素雰囲気下で熱処理を行った後、１３００℃、２時間、アルゴン（Ａｒ）雰囲気中において形成したサンプルＢ’においても、接着界面に２１００オングストロームの酸化膜層が観察された。

【００４７】また、１１００℃、２時間、窒素雰囲気下で熱処理を行った後、接着された半導体基板の一方を接着界面から１０μｍの厚さに薄膜化を行った後に、１３００℃、２時間、アルゴン（Ａｒ）雰囲気中で形成したサンプルＣ’は、接着界面に２０２５オングストロームの酸化膜層が観察された。

【００４８】この結果から、所定厚さの酸化膜層が形成され、前記酸化膜層とともに自然酸化膜層が形成された貼り合わせ半導体基板においても、少なくとも一方の半導体基板が接着界面から１０μｍの厚さまで薄膜化された後、アルゴン雰囲気中で、１３００℃、２時間の高温熱処理を施すことにより、前記薄膜化された半導体基板から１０μｍの深さに存在していた酸化膜層から８５オングストロームの酸化膜層が除去されていることが確認できた。

【００４９】従って、２枚の半導体基板を室温で貼り合わせた後、前記貼り合わせた半導体基板の接着界面から１０μｍの厚さに半導体基板を研削・除去し、その後、酸化性以外の雰囲気中で１３００℃、２時間の高温熱処理することにより、基板中の酸素が外方拡散され、接着界面に存在する酸化膜層が、半導体基板の低濃度領域に拡散されて、酸化膜層が介在しない貼り合わせ半導体基板を形成することができる。

【００５０】次に、半導体基板中の酸素濃度が14×10^{13}ｃｍ$^{-3}$の半導体基板を用いて、貼り合わせ半導体基板を形成し、その後、酸化性以外の雰囲気中、１３００℃の高温で、２時間又は４時間、熱処理した場合、酸素の外方拡散により、表面から深さ方向に酸素濃度がどのように変化するか調べた。

【００５１】図５は、酸素濃度を深さ方向に測定した結果を示す図である。

【００５２】具体例１，２により、表面から１０μｍの位置で酸化膜（８５オングストローム以下の酸化膜）が消滅していることから、この位置での酸素濃度は、3×10^{17}ｃｍ$^{-3}$であり、これ以下の酸素濃度であれば、８５オングストローム以下の酸化膜は、半導体基板中に拡散し、消滅する。また、１３００℃で４時間の熱処理を行った場合、酸素の外方拡散が進み、酸素濃度3×10^{17}ｃｍ$^{-3}$となる位置は、表面から２０μｍの位置となり、表面から深い位置で消滅させることができる。

【００５３】このように、半導体基板中の酸素濃度が低いほど、また酸素の外方拡散が多いほど、半導体基板表面から深い位置の酸化膜が除去される。

【００５４】従って、半導体基板中の酸素濃度の低酸素化によって、接着界面に存在する酸化膜を半導体基板中に拡散させて、酸化膜が介在しない貼り合わせ半導体基板を形成することが可能となる。

【００５５】

【発明の効果】本発明は、以上説明したように、２枚の半導体基板が接着されて形成される酸化膜を介さない貼り合わせ半導体基板の製造方法において、２枚の半導体基板を接着する工程と、前記接着された半導体基板の少なくとも一方の面を研削・研磨する工程と、前記接着された半導体基板を、酸化性以外の雰囲気中において、所定条件温度にて熱処理する工程を備えた酸化膜を介さない貼り合わせ半導体基板及びその製造方法である。

【００５６】このように、２枚の半導体基板を接着して形成する貼り合わせ半導体基板において、例えば、接合面に自然酸化膜を形成して親水性を持たせる表面処理を行った後、２枚の半導体基板を貼り合わせ、その後、例えば、室温中で貼り合わせられた半導体基板に１１００℃～１２００℃の高温熱処理を行う。このときに貼り合わせられた半導体基板の接着界面には、自然酸化膜による酸化膜層が存在していることとなる。その後、少なくとも一方の基板の厚みを所定厚さに研削・研磨した後、酸化性以外の雰囲気中で、所定温度、例えば、１１００℃～１３００℃の高温熱処理を施すことにより、研削・研磨で所定厚さに薄膜化された基板のシリコン層中の酸素濃度は、外方拡散により低濃度化される。このため、接着界面に存在する酸化膜は、低濃度化されたシリコン層中に拡散しやすくなる。従って、貼り合わせられた半導体基板の接着界面には、全く酸化膜を介さない貼り合わせ半導体基板を得ることができる。

【００５７】また、貼り合わせられる２枚の半導体基板の少なくとも一方の半導体基板の表層の酸素濃度が、3×10^{17}ｃｍ$^{-3}$以下である半導体基板を用いることにより、所定温度、及び、処理時間の条件の熱処理条件で、基板中の酸素が、外方拡散により、表面にいくほど酸素濃度が低下し、この基板表面の酸素濃度低下領域に存在する酸化膜が基板中に拡散されて、接着界面に全く酸化膜が介在しない、貼り合わせ半導体基板を得ることができる。

【図面の簡単な説明】

【図１】本発明の具体例に係り、貼り合わせ半導体基板の製造方法を示す工程図である。

【図２】本発明の具体例に係り、各処理によって形成した貼り合わせ半導体基板の接着界面に介在する酸化膜の膜厚を測定した図である。

【図３】本発明の具体例に係り、形成した貼り合わせ半導体基板のサンプルＣの断面をＴＥＭで測定した図であ

る。

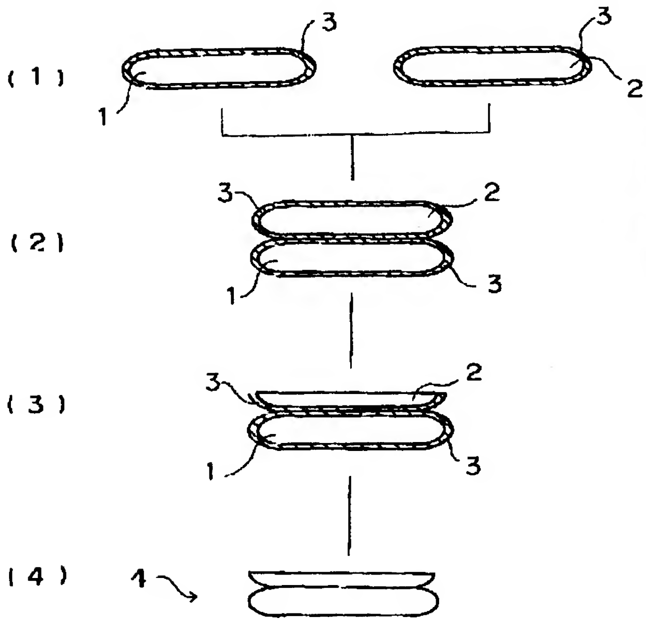
【図4】本発明の第2の具体例に係り、各処理によって形成した貼り合わせ半導体基板の接着界面に介在する酸化膜の膜厚を測定した図である。

【図5】本発明の具体例に係り、半導体基板中の酸素濃度と、酸化膜が消滅する表面からの深さの関係を示す図である。

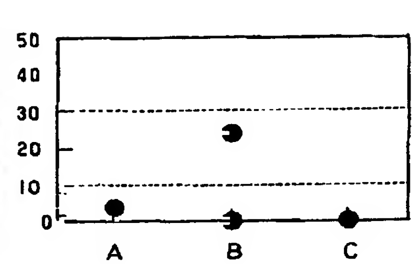
【符号の説明】

1　半導体基板
2　半導体基板
3　自然酸化膜
4　貼り合わせ半導体基板
5　貼り合わせ半導体基板

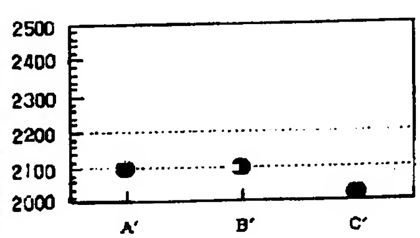
【図1】



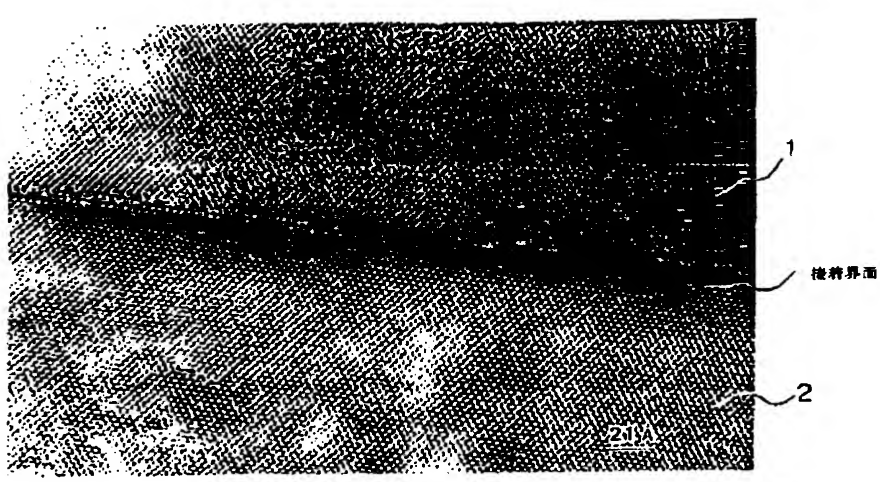
【図2】



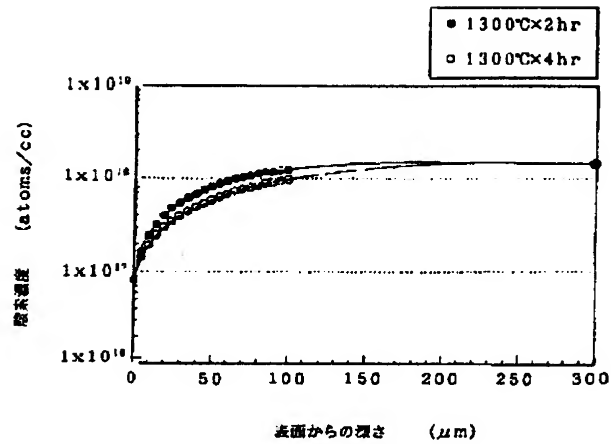
【図4】



【図3】



【図5】


● 1300℃×2hr
○ 1300℃×4hr
1x10^19
1x10^18
1x10^17
1x10^16
酸素濃度 (atoms/cc)
0
50
100
150
200
250
300
表面からの深さ (μm)